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INVESTIGATING THE INFLUENCE OF PRODUCT PERCEPTION AND GEOMETRIC FEATURES

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ABSTRACT

Research in emotional design and kansei engineering has shown that aesthetics play a significant role in the appeal of a product. This paper contributes to establishing a methodology to identify the relationships between: perceptions, aesthetic features, *desire to own* and background of consumers. Surveys were conducted with 71 participants to gather their perceptions of 11 vase concepts. Advanced statistical analyses, including mixed models, were applied to allow generalisation of the results beyond the data sample. Significant relations between the *desire to own* a product and how the product is perceived were found (the *desire to own* was found to be related to *beautiful, expensive, elegant, exciting, feminine, common* and *dynamic* vases); as well as between the perceptions and the parameters describing the form of the vases (a vase was perceived as *beautiful* if it had many curved lines, was simple and tall). An *automated mixed model* analysis was conducted and revealed that general rules can be found between aesthetic features, perceptions and ownership, which can apply across gender and culture. The findings include design rules that link aesthetic features with perceptions. These contribute to research as guidelines for design synthesis and either be implemented via shape grammars or parametric modelling approaches. These rules are also interesting for 3D printing applications, especially important when the consumer is the designer. Some of these design rules are linked to the *desire to own* a product and they have implications for industry, they offer guidelines to creating attractive products that people want to own.

KEYWORDS

Emotional design, kansei engineering, aesthetics, perception, product form and geometry.

1. INTRODUCTION

Product differentiation is essential in today's highly saturated consumer markets where products compete against each other with very similar functionalities. Aesthetic appeal and emotional attachment are approaches companies use nowadays to provide consumers with added value. In the last years, much attention has concentrated on understanding consumers' needs and demands in a more accurate way. The design field has focused on understanding consumers' emotional needs and therefore researchers have started to investigate perceptions and emotions of users from their interaction with products (Norman 2004). That knowledge was used to generate new designs that appeal to their target consumers and hence stand out from the many competitors in the market. However, research has shown that there is a misalignment between designer's intentions and consumer's perceptions (Hsu *et al*. 2000; Ahmed and Boelskifte 2006). Hsu *et al*. (2000) investigated how professional designers and users perceived the same product forms. Their results showed that there is a significant difference between how the designer intends a product form to be perceived and how the users perceive from it. They also found a difference in the way the products (in this case telephones) were perceived between consumers and designers. They concluded that designers respond to more subtle changes in the form than users do. Similarly, Ahmed and Boeslkifte (2006) found that what the designer of the product wanted to convey with the product and what the users understood or perceived from it was not aligned. In this case, the design students generated a product with an accompanying mood board. They found that no complete agreement on what the designer intended to communicate was described by the users when asked to evaluate the product. That is, designers are not always successful in conveying their intentions through the aesthetics of their products.

One means designers communicate with consumers is through the aesthetics of the products they design, which is often the first interaction consumers have with the product. To achieve or convey a specific message, designers modify and manipulate the aesthetics appearance of the product (shape, colour, material, etc). Knowing which aesthetic elements have a big impact on consumer perception and how these perceptions can be achieved is crucial for designers since they can then emphasize or modify the shape to achieve the target perception. However, as explained in the above paragraph, designers and consumers do not always perceive products in the same way. Designers need support to generate new design alternatives that convey the intended message with the aesthetics of their products so consumers perceive it as intended.

The research question is therefore, to understand how the aesthetics (shape, material and colour features) of objects influence consumer's perception of products and how those perceptions impact the *desire to own* a product. Identifying the relationships between perceptions of a product and its aesthetic features can support both understanding and defining the appearance of a product so that it is attractive to consumers. Identifying the aesthetical features that are perceived as attractive can lead to understanding why consumers would prefer one product over another (within the same product category or type of function). Additionally, investigating if the background of the consumers (i.e. country of origin, age, gender, etc.) influences how products are perceived can assist designers in generating products that are tailored for a particular segment. Some contradictions were found in literature, where some authors find differences in perceptions (Choungourian 1968; Choungourian 1969; McManus *et al*. 1981; Grieve 1991; Ou *et al*. 2004), while others find similarities in perceptions across consumer backgrounds (Ou *et al*. 2004; Blijlevens *et al*. 2009).This understanding can be used to develop guidelines for a product's appearance that either transcend cultures or target them.

The paper presents a methodology to understand the connection between three main elements: 1) the aesthetics of products (form) followed by; 2) the consumer perceptions from products; and 3) the desire of a consumer to own a product. Additionally, the influence of the background of the participants is also investigated. The relationship between these elements is found through the use of several statistical analyses. The results show that there exist relationships between aesthetics, perceptions and *desire to own*, which can be used as guidelines for design. The paper is structured as follows: First, a literature review including three main areas (aesthetics, perceptions and consumer psychology) is

presented. This is followed by the aims and hypotheses of the empirical case study utilising vase concepts. The data collection and data analysis approach and the results are presented. Finally, discussion and conclusion section conclude the paper.

2. LITERATURE REVIEW

In order to understand how aesthetics (or geometry and the defining features of objects) influence the perception of products and whether or not that perception can impact the purchase intention of a product, a literature review was conducted and is presented below. The literature review starts by presenting approaches to how people and products interact. Then it describes the three main topics covered in this research: 1) the aesthetics of products; 2) perceptions from products; and 3) consumer psychology (related to the *desire to own* a product) and concludes with previous research that connects these three areas.

Jordan (2000) states that the reason people want to own products is that they ultimately want to feel pleasure; where pleasure is the sensation induced by the satisfaction of what it is perceived to be good and desirable and takes place if there is an interaction between the product and the person (pleasantness approach). Products are a source of pleasure and people can obtain practical benefits (the outcome of performing a task), emotional benefits (when products affect the mood of people) and hedonic benefits (sensory and aesthetic pleasure obtained from products). Desmet (2010) describes that individuals classify something as potentially beneficial or harmful during their evaluation of a product (appraisal approach). Desmet describes the emotional response as determined by the evaluation and interpretation of events and this appraisal is considered a non-conscious evaluation as it mediates between events and emotions. This explains why different people can perceive different emotions for the same event. It is possible to distinguish between the usefulness appraisal (when the event supports or obstructs reaching a goal), the pleasantness appraisal (when the event provides pleasure or pain) and the rightfulness appraisal (when the event meets or exceeds expectations). The Process-level approach, where there are three levels of information processing is described by Norman (2004). These are:

- The visceral level: where the initial impact of a product takes place through appearance, touch and feel; this is an automatic layer (i.e. not conscious) and is almost the same all around the world.
- The behavioural level: where people perceive pleasure and effectiveness of use, it is not conscious and it is sensitive to experiences, training, education and culture.
- The reflexive level: where rationalization and intellectualization of a product takes place and is sensitive to experiences, training, education and culture of an individual. It is conscious and it is the highest level of feeling, emotion and cognition. It is about self-image, personal satisfaction and memories and is in the mind of the beholder.

The above three approaches explain the relationship between products and consumers with a different perspective. Despite the different approaches, it is possible to see that the authors agree on how products are perceived. All three approaches differentiate between the emotional aspects elicited by products, the functional aspects and the aesthetic aspects. The first contact with the product is through the sensory system, which provides the first impression or perception from the product. This first stage is automatic and shared around the world. From there, the person evaluates the use of the product which is dependent on people's experiences and culture. At the final stage the person reflects about the object and its meaning in relation to him or her and this is where emotions appear. At this last stage, emotions can vary from person to person since this is dependent on the individual's own situation. This research focuses on the aesthetics of products and the influence the shape of products has on perceptions. This area of research falls within the hedonic benefits category (Jordan 2000), the pleasantness appraisal category (Desmet, 2010) and the visceral level of information processing category (Norman 2004).

2.1. Aesthetics

In the interaction between consumers and products, aesthetics play an important role in the evaluation of products as it is the first interaction consumers have with objects. Within the context of design research, aesthetics refers to the features of a product that create its appearance and have the capacity to generate immediate responses during the experience of an object through the sensory system (Lawson 1983). The response to aesthetics is described as rapid, involuntary and can be biased positively or negatively (Ulrich 2006). This initial response is also referred to as the visceral response in emotional design literature (Norman 2004). The appearance features of products include materials, colour, proportion, ornamentation, shape, size and reflectivity (Brunel and Kumar 2007). These features, in the right combination, can provide pleasure or delight from the sensory system regarding a physical object (Hekkert 2006). Aesthetics also give a sense of quality to the product as attractive things do not occur at random, it takes time to make them look appealing (Ulrich 2006). Aesthetics can be understood from two different perspectives, these are not mutually exclusive: 1) The Evolutionary aesthetics approach, which describes aesthetic responses as the result of evolution. That is, humans developed a preference for those elements that were good for them, such as food and a safe environment, and they developed a system to quickly discern what was good from what was bad. However, this does not mean that all aesthetic perceptions are shared around the globe. 2) The Cultural aesthetics approach states that aesthetic preferences of individuals are influenced by the social environment that they live in (Ulrich 2006). In short, there are some aspects about aesthetics that are shared but other aspects are learned from the culture one is born in.

2.2. Perceptions

Although the field is called emotional design, it is important to differentiate between emotions and perceptions when investigating the relation between products and people. According to Myers (2004), emotions constitute the mental experience of an individual when interacting with internal (physical) and external (environment) stimuli. Emotions (e.g. happiness) are conscious experiences that constitute evaluations of external stimuli based on physical body responses (Myers 2004). Emotions are short in duration, from seconds to minutes (Johnson 2009), and can influence both thought and behaviour (Cherry 2012). No agreement has been reached on defining the basic emotions by researchers and therefore different sets of emotions are defined by each. However there is agreement that there is a finite number of basic emotions, typically between 6 and 8 (Ortony and Turner 1990). Other emotions are considered to be combinations of the basic ones.

Perceptions of products (e.g. that something is *beautiful*) are what it is noticed from the products (Goldman 1995). In contrast to emotions, there are no basic set of perceptions, nor a finite list, however attempts have been made to classify perceptions. Goldman (1995) proposed eight categories for terms that describe the perception of products where emotional is one of these categories. The eight categories are: broadly evaluative, formal, emotional, evocative, behavioural, representational, perceptual and historical. Some of these categories are perceptions that rely upon the experience of the consumer e.g. the historical category, or compare against other products. For this research perceptions were selected that were not historical.

2.3. Consumer psychology

Research in consumer behaviour is also relevant to understand emotional design offering a complimentary view to the visceral responses when purchasing products. Consumers present different types of behaviour when presented with a new purchase opportunity. Some show a rational behaviour while others are more emotional or compulsive. An emotional or impulsive purchase is one where, consumers show very limited cognition, a very high affective involvement and, the purchase was not previously planned (Weinberg and Gottwald 1982). The rational approach takes place when the person first identifies a need and then goes through a number of steps to determine which item will satisfy his/her needs best and then decides if to purchase or not (Berkowitz *et al.* 1994). The level of involvement of the consumer in the purchase decision can also vary from consumer to consumer and it's related to the level of personal, social or economic risk. The higher the risk, the higher the involvement of the person and the more time he or she will spend searching for information (Berkowitz *et al.* 1994). There are a number of factors that have an influence on the buying behaviour, these are: 1) personal factors (individual); 2) psychological factors (motivation and personality, perception, learning, values, beliefs and attitudes, lifestyle); and 3) socio-cultural factors (personal influence, reference groups, family, social class, culture, subculture) (Berkowitz *et al.* 1994). Blijlevens *et al.'s* research (2009), provides

insight on how consumers perceive product appearance. They allowed consumers to group several products into categories and then identified product attributes for each category. They found the attributes modernity, simplicity and playfulness were found to be universal and valid across product categories. This research implies that some attributes transcend product categories. This methodology is equivalent to the approach we adopt. Consumers feel varying levels of attachment towards the products they own, resulting in some products being kept whilst others are disposed of (Schifferstein and Zwartkruis-Pelgrim 2008). There are numerous reasons for disposing of a product including: that the products look out-of-date, they are not compatible with other products and the availability of new products (Schifferstein and Zwartkruis-Pelgrim 2008). Consumer attachment is defined as the emotional connection a person feels towards a product; this bond is special and thus if the product becomes damaged or lost, the consumer will experience an emotional loss given that it cannot be replaced (Schifferstein and Zwartkruis-Pelgrim 2008). Time influences not only the attachment to products, but also ownership and consumer emotions (Dwayne Ball and Tasaki 1992; Schifferstein and Zwartkruis-Pelgrim 2008). A study carried out to identify the factors affecting attachment to products during the different stages of the ownership of the product showed that recently acquired products (those owned under 1 year) and products owned over 20 years have a high level of attachment for people (Schifferstein and Zwartkruis-Pelgrim 2008). Memories and enjoyment were the only parameters found to positively influence attachment to products, but their influence varies according to the length of ownership. Enjoyment is the driver for attachment for new products, while memories are important for products owned for a long period of time. Evoking enjoyment or facilitating the creation of memories is the way to make people become attached to a product and the way to evoke enjoyment is by being useful and evoking sensory and aesthetic pleasure (Schifferstein and Zwartkruis-Pelgrim 2008).

2.4. Studies on perception of aesthetics

Understanding how shape and form of products evoke desired perceptions is of interest to designers, as the perception of a product as intended by the designer and the perception of the users can differ indicating that designers cannot always predict the perception of their products by users as explained in the Introduction (Hsu *et al*. 2000; Ahmed and Boelskifte 2006). Research in this area shows that many methodologies have emerged to support the process of designing to target consumer's preferred perceptions. These are presented here.

In the field of consumer marketing, Bloch (1995) showed the importance of the form of the product in communicating information to the consumer in the marketplace. Gover and Schoormans (2005) investigated the symbolic meaning of products through product personality traits. These traits are perceptions (i.e. honest, aggressive, arrogant, masculine, etc.) and some were found to positively correlate to consumer preference if they matched the consumer self-image. In short, they clearly pointed towards perceptions as the way to understand the relationship between the form of the product and the consumer perception. In the field of emotional design, several methodologies to design for emotions were proposed .Van Bremen *et al.* (1998) proposed a method following the analogy of communication. The method proposes that first it is necessary to understand how shape invokes feelings, in order to later be able to apply the knowledge to systematically design aesthetically pleasing products. They explain that shape, composition and physical attributes (colour, texture and materials) are the most influencing parameters of the aesthetics of a product (Van Bremen *et al*. 1998). Building on that approach, Achiche and Ahmed-Kristensen (2011) proposed a method based on Gestalt rules to analyse shapes. They measured different geometric parameters from objects and relate them with if-then rules which could then be used to explain a series of adjectives (perceptions). Hsiao and Chen (2006) also worked in this direction and were able to identify common relations between shape elements and emotions across three product categories (cars, sofas and kettles). They defined shape features (e.g. line) and feature levels (e.g. straight, curved, straight and curved). The Kansei Engineering methodology, a product design methodology equivalent to emotional design, translates impressions, feelings and demands from consumers into design parameters and solutions. First, designers select the product concept and target user group and translate their needs into kansei feelings. Following this, the design attributes relevant to those feelings are identified (Colwill et al. 2003). Schütte and Eklund (2005) propose a series of design rules, stating that the combination of properties gives a certain impression. These rules were obtained after combining the physical properties of the object and the words (mainly adjectives) used to describe them through SD scales and statistical analyses. The procedure lists all the physical product properties and the words describing the product. Following this, experts from companies reduce the number of properties to contain only important properties. Osborn *et al.* (2009) used the preferences of consumers regarding products to design new objects targeting the

consumer perception. This was done by first defining the products space, accounting for the general form of the product and then breaking the form into characteristics. The preferred qualitative attributes of the form were captured and then used to generate new designs that matched the preferences of the consumers. They used images of products rather than words to describe them. Other approaches involve the consumer directly in the generation of the product's final form, for example by first defining the intended perception of the product and then allowing the consumer to interact with a computer software until he or she reaches the product form they expect for the defined perception (Yanagisawa and Fukuda 2005). In a similar approach, designers modify the factors identified as having significant influence to get closer to the intended perception that is defined at the start (Lai *et al*. 2005). Blijlevens *et al.* ask consumers to classify products from different categories as belonging to groups depending on their perception, and these were compared with the ones made by designers. The study showed that non-professionals perceive fewer differences from product appearances than professionals do (Blijlevens *et al.* 2009). The study also highlighted that there are properties that can be perceived across product categories. Hekkert (2014) has recently developed a Unified Model of Aesthetics (UMA) to integrate the various dimensions that can have an impact on the experience of the product. The purpose of this programme is "to develop and test a Unified Model of Aesthetics that is capable of explaining our everyday aesthetic preferences for designed artefacts".

As described above, most of the methodologies focus upon understanding the influence of the physical properties of the products, i.e. the aesthetics, to obtain more appealing products and very little attention is given to the background of the participants and the possible effects on the perception of design, i.e. focusing primarily through an evolutionary aesthetic approach rather than cultural. Only few researchers have looked into and found cultural differences in the understanding of product properties, particularly the meanings associated to colours (Choungourian 1968; Choungourian 1969; McManus *et al*. 1981; Grieve 1991; Ou *et al*. 2004). As differences are found in colours, this suggests that some other product properties could also be influenced by culture. However, the Gestalt rules of perception are known to transcend cultures as they are based on how people perceive and interpret the world around them (Wertheimer 1938). Additionally, research from Blijlevens *et al.* (2009) has shown that some perceptions from products were similar for different consumer groups, suggesting there are universal perceptions that are not influenced by culture. This contradiction makes it interesting to study the influence of the background of the consumers on the *desire to own* a vase and on perceptions related to them.

3. RESEARCH AIM AND MOTIVATION

A lack of support in generating shapes for products to evoke a specific perception was identified in literature. The current process relies on the designer's intuition or experience to develop the form of the product. One of the problems with this is that designers and consumers do not always share the perception from the same shapes (Hsu *et al*. 2000; Ahmed and Boelskifte 2006). The relationship between the form and the perception (or in some case emotions) evoked has been partially but not fully investigated (Schütte and Eklund 2005; Hsiao and Chen 2006; Achiche and Ahmed-Kristensen 2011). Few studies link perceptions to aesthetic features. An increased understanding of this can lead to new research knowledge in the area of design for emotions, in addition to generating guidelines that can support in achieving the desired specific perceptions of a product. Hence this together with understanding the relationship of the perception evoked to the *desire to own* a product provided the motivation for the study conducted in this paper. Additionally, investigating the influence of the background of consumers (eg. age, gender, style, etc) assists in understanding if perception guidelines can transcend backgrounds or should be specific for target groups.

Therefore, this research aimed to:
1) Identify perceptions that influence the *desire to own* a product.
2) Investigate the relationship between aesthetic features that influence different perceptions.
3) Relate the aesthetic features (from 2) to the perceptions identified in 1that influence the *desire to own* a product.
4) Investigate the influence of the background of the participants on perceptions and on the *desire to own*.

3.1. Hypotheses

A number of hypotheses connecting the different variables were proposed prior to the data analysis. These are presented here. A number of statistical approaches were adopted to measure the hypotheses, these are reported here, but are described in depth in section 4.3 Data analysis.

Hypothesis 1 (H1):

According to consumer psychology, consumers purchase based on stimuli from products (Weinberg and Gottwald 1982) and will always choose the product that is more attractive between two of equal price and function (Kotler and Rath 1984). It is therefore expected that positive perceptions will positively correlate to the *desire to own* a product. From the list of perception tested, four perception terms were identified as positive perception. Therefore the following hypothesis was derived: Hypothesis 1 states that perception: *beautiful, elegant, exciting* and *expensive* are expected to positively correlate to the *desire to own* a vase. Additional neutral perceptions, e.g. *feminine* and *artificial* among others, have been added to the test to act as control.

Measure: correlation coefficients from Correlation Coefficient Analysis (CCA), Principal Component Analysis (PCA) and Factor Analysis (FA). The CCA correlates between perceptions and the *desire to own*. PCA will identify correlations between the perceptions and the *desire to own* and identify the perceptions that move together (i.e. influence *desire to own* in the same way), some of which will be related to the *desire to own*. A plot will provide a visual representation of which perceptions are related (vectors having similar direction). The FA will give correlation coefficients between the perceptions and the *desire to own* and will show which perceptions are related (identifying constructs). Tables with correlation coefficients will be shown to demonstrate the relationship between the variables of the factors. Plots will additionally be used to illustrate what perceptions are related and move together with the *desire to own* a product. A correlation value (r) is considered relevant when the value is above 0,7 (or -0,7) and the p-value is below 0.05.

Hypothesis 2 (H2):

Previous research (Schütte and Eklund 2005; Hsiao and Chen 2006; Osborn *et al*. 2009; Achiche and Ahmed-Kristensen 2011) has shown that some aesthetic properties influence the perception of products. It is therefore expected to find relationships between perceptions and aesthetic features for vases. From the literature it was possible to develop expectations linking some of the perception terms to aesthetic features (Perez Mata and Ahmed-Kristensen 2015). This was from reviewing a number of studies and extracting these relationships. The set of hypotheses proposed here are:

- H2a: *Beautiful* vases are expected to have more curves than straight lines, be simple and tall. It was assumed that *beautiful* would relate to more curves than straight line, as *aggressive* has previously been associated with more straight lines than curves (Achiche and Ahmed-Kristensen 2011) (see H2b) and it is expected that *beautiful* in the case of vases would therefore not have the characteristics belonging to *aggressive*. In addition, it is expected that simplicity will positively influence *beauty* of vases as expressed by the simplicity principle (Wertheimer 1938; Pham 1999; Roussos and Dentsoras 2013) and the principle of Maximun Effect for Minimum Means (Hekkert 2006) which states that a visual design is *beautiful* or pleasing to the eye when simple design features provide a lot of information. Furthermore, research by Hsiao and Chen (2006) on three product categories, namely kettles, sofas and cars, has shown that simplicity is influenced by the element amount. Therefore, simplicity was considered an important aspect of *beauty*. In addition, scale and proportion is known to influence aesthetic preference (Pham 1999) and the golden ratio is known for its *beauty* since ancient times. For the case of vases, tall is expected to be a feature of *beautiful*.
- H2b: *Aggressive* vases are expected to have high number of lines over curves, high number of acute angles over obtuse angles and low regularity level (or symmetry). This is expected based on previous research in 3D forms (Achiche and Ahmed-Kristensen 2011) where those features (number of lines, angles and regularity level) influenced the perception of *aggressive*. Those rules are expected to show the same behavior on the vases.

- H2c: *Expensive* vases are expected to be tall. This is expected based on previous research looking into rocker switches (Schütte and Eklund 2005), which has shown that the cheap/stiff factor was influenced by the form ratio. Narrow rocker switches positively influenced the cheap/stiff factor. For vases, it is expected that a tall (narrow) form ratio will also influence the perception of expensive (which is the opposite of cheap) as vases are generally tall.
- H2d: *Masculine* vases are expected to have more straight lines than curves and more sharp corners. This was expected as *masculine* has previously been associated to lines and sharp corners across a number of product categories (i.e. kettles, sofas and cars) (Hsiao and Chen 2006). For vases, straight lines and sharp corners are expected to be a feature of *masculine*.
- H2e: *Dynamic* vases are expected to have more curves than straight lines. It is expected that *dynamic* for vases will relate to curves as previous research has shown that changes in curvature influence the *dynamic* perception of products (Pham 1999). For vases, curves are expected to be a feature of *dynamic*.
- H2f: *Organic* vases are expected to have more curves than straight lines. It is expected that *organic* for vases will relate to curved lines as previous research has shown that curved lines and surfaces are related to an overall *organic* form across a number of product categories (i.e. kettles, sofas and cars) (Hsiao and Chen 2006). For vases, curves are expected to be a feature of *organic*.
- For the four following perceptions: *Uncommon, exciting, elegant* and *mature* there was no literature found and therefore, no hypotheses were formed. However, this is a rather exploratory analysis so more relations are expected to be derived from the analyses.

Measure: correlation coefficients from Correlation Coefficient Analysis (CCA) and Multiple Regression Analysis (MRA). The CCA will give individual independent correlations between the perceptions and the product characteristics. The MRA will give correlations of groups of product characteristics and the individual perceptions. That is, each perception can be correlated to several product properties, and will only be perceived as such when all product properties are present simultaneously. Tables with correlation coefficients will be shown to demonstrate the relationship between the variables. A correlation value (r) is considered relevant when the value is above 0,7 (or -0,7) and the p-value is below 0.05.

Hypothesis 3 (H3):

From previous research, the influence of the demographic information or background of the participants on the perception of shape is not clear. Some authors found cultural differences in the understanding of product properties, particularly in the meanings associated to colours, while others found aspects that are shared across products and backgrounds. Choungourian (1969) found differences in colour preference for different age groups, while *McManus et al.* (1981) found differences in colour preference between males and females. However, Ou *et al.* (2004) found no significant differences between male and female data linking colour and perception, while differences were observed between British and Chinese participants for some perception terms (i.e. tense-relaxed and like-dislike). Differences in colour perception among different cultures were also found between Americans and Kuwaitis (Choungourian 1968) and between Americans, South Africans and Senegalese (Grieve 1991). Additionally, previous research by Blijlevens *et al.* (2009) found that different product perceptions (i.e. modernity, simplicity and playfulness) were stable across consumer groups of different age and gender and product categories (including CD payers, bathroom scales, desk lamps, wall clocks, microwaves, vacuum cleaners, cell phones and chairs) leading them to concluded that those attributes were universal. Hypothesis 3 states that the *desire to own* a product is expected to be different for people from different countries of origin (due to cultural differences). Other background terms such as gender, age, design background and preferred style were also included in the analysis but the influence is expected to be derived from the tests.

Measure: results from the lmerTest analysis will show relevant variables from the background of the participants that have an influence on the *desire to own* a product, either in isolation or in interaction with other variables (aesthetics or perceptions). This test is specifically targeted for categorical data. Tables with correlation coefficients will be shown to demonstrate the relationship between the variables. A correlation value (r) is considered relevant when the value is above 0,7 (or -0,7) and the p-value is below 0.05.

Hypothesis 4 (H4):

The collaborative case company assumed that vases need to be attractive to women as in the majority of cases they are the buyer of the vases and therefore targeted the design to be appealing to women. Additionally, McManus (1981) found evidence of gender differences on colour preference suggesting that gender is a factor in product design preference. Hypothesis 4 states that the *beauty* ratings of vases are expected to be higher for women than men. Other background terms such as country, age, design background and preferred style were also included in the analysis but the influence is expected to be derived from the tests.

Measure: results from the lmerTest analysis will show relevant variables from the background of the participants that have an influence on the *beauty* of a product, either in isolation or in interaction with other aesthetics variables. The perception of *beauty* from a product was studied because it was found to be very significantly related to the *desire to own* a vase. Tables with correlation coefficients will be shown to demonstrate the relationship between the variables. A correlation value (r) is considered relevant when the value is above 0,7 (or -0,7) and the p-value is below 0.05.

Figure 1 shows the four areas investigated and connected through the hypothesis described above.

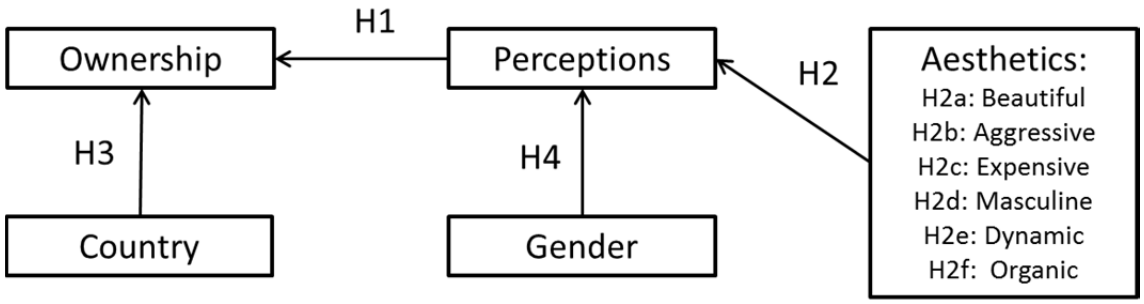

Figure 1 Variables studied connected by hypotheses

In order to investigate the hypotheses, each of the main factors has been divided into smaller measures. For the aesthetics of products, different shape and geometric variables have been considered (i.e. curves, straight lines, curved and sharp corners, etc.). A number of perceptions (e.g. *ugly/beautiful, cheap/expensive, masculine/feminine*, etc.) have been considered and they are selected based on the previous research by the second author (Ahmed and Boelskifte 2006; Achiche and Ahmed 2008) to be perceptions that are easy to understand and belong within different categories of perceptions (as defined by Goldman (1995)). Perceptions were carefully chosen to avoid any that are influenced by previous experiences and encounters with similar products, i.e. none were selected from the historical category of perception.

4. METHODOLOGY

This study is based upon concepts of vases from a Danish design-driven company based on the Scandinavian design philosophy. The concepts of the vases were produced by professional industrial designers (predominantly Scandinavian). The designers were given the brief to create an *organic* and *feminine* vase. The designers proposed several concepts and the company was responsible to select which one would be taken further to be manufactured and eventually sold in the market. From previous research it was found that it is difficult for users to assess products for their aesthetics if they are unsure about the functionality or usability of the product (Ahmed and Boelskifte 2006). Hence, vases were selected as they are products with relatively simple functionality (and usability) and with high aesthetical appeal, allowing the research to focus on the aesthetical appeal. The data collection approach, followed by the data preparation (using cluster analysis) and the data analysis methods are described below.

4.1. Data collection

Data was collected from a survey with 11 vases through an online social network. A total of 97 participants undertook the survey which took between 15 to 20 min. to complete. However, only 71 participants answered all 126 questions and only these are analysed in this paper. Applying Cochran's formula for categorical data: $n_0 = (z^2 * p * (1 - p)) / c^2$ where n_0 is the sample size, z is the confidence level (set to 1,96 for a 95% confidence), p is the estimated proportion of an attribute that is present in the population (chosen to be 0,5 which is the worst case scenario) and c is the confidence interval (Cochran 1977). For our survey 71 participants are able to represent the Danish adult population of 2 Million people with a 95% confidence level and a confidence interval of 11,63%. In the survey, participants were asked to provide information of their background namely: the country that they were from, age, gender, if they had a design background and the style (design style) that they most closely associated themselves with. For the style question they were given the following options to select between: Scandinavian, Minimalistic, Romantic/French inspired, Country/Traditional and others, these styles were selected as they were defined by the company. The participants were asked to rate the perceptions of each of the 11 vase concepts (see Fig. 2) for ten selected pairs of opposite perceptions (summarised in Table 1). The perceptions were based on prior work, and two checks were performed before choosing them: 1) the perceptions were clear and 2) the perceptions did not rely on associations (of the participant). Only the perceptions that fulfilled those criteria were used (Ahmed and Boelskifte 2006; Achiche and Ahmed 2008). If the perception was not understood correctly, the participants would rate in the middle of the Semantic Differential scale, which was not the case, and the perception would not be significant for any analysis. Semantic Differential scales (SD scales) (Osgood *et al.* 1957) with seven levels were used by participants to rank each of these perceptions regarding the vases (see example in Table 2). SD scales were used to obtain the information on perceptions, as the validity of the scales is accepted within the research field and they are widely used in similar studies.

Fig. 2 Images of the 11 vase concepts ordered from lower to higher desire to own

The participants were also asked whether they had a *desire to own* the product, hence allowing the relationship between the *desire to own* the product and the perceptions evoked from the product to be investigated (hypothesis 1). For this question a three point SD scale was employed: no (-1), maybe (0), yes (+1). The ownership question was based on the intention of participants to own a product (and no information regarding the cost of the product was presented), hence these responses can differ from actual purchasing decisions.

Table 1. The ten selected pairs of opposite adjective used to assess the perception of the vases

1. Ugly / Beautiful	6. Clumsy / Elegant
2. Aggressive / Passive	7. Feminine / Masculine
3. Cheap / Expensive	8. Youthful / Mature
4. Common / Uncommon	9. Dynamic / Static
5. Dull / Exciting	10. Organic / Artificial

Table 2. Example of a SD scale with seven levels for adjective pair ugly / beautiful

Very Ugly	Quite Ugly	Slightly Ugly	Neutral	Slightly Beautiful	Quite Beautiful	Very Beautiful
-3	-2	-1	0	1	2	3

4.2. Data segmentation: Ownership dendrogram

Prior to analysing the data, a Cluster Analysis (CA) was performed on the ownership value (the response to the question of *desire to own* the vase) using the Ward method. This allowed the participants to be grouped according to the similarity of their replies to the ownership of the 11 vase concepts and then for these groups to be analysed to identify similarities (e.g. in background). The CA was conducted to facilitate the identification of relations between the *desire to own* and perceptions. The three clusters that emerged after the CA are presented in Fig. 3. The smaller the U shape height between two data points or participants in the graph indicates the closer their replies to the ownership of the 11 vases. In contrast, the greater the U shape height, the greater the difference in their responses. The ownership values were (-1 for *don't want to own*, 0 for *maybe want to own* and 1 for *want to own*).

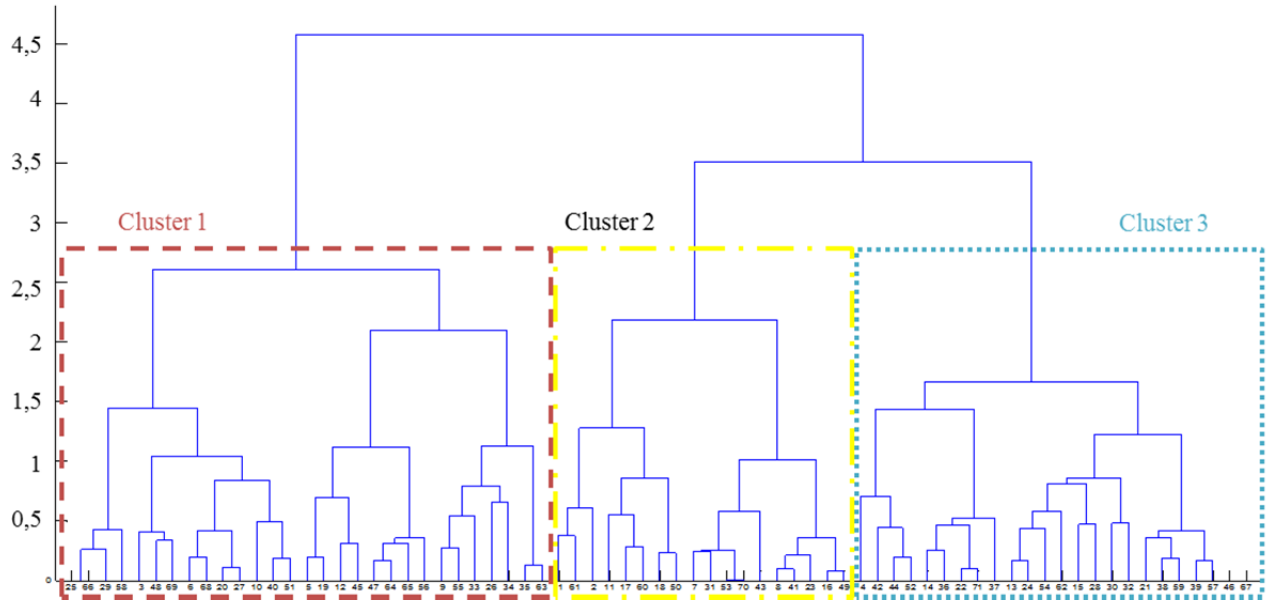

Fig. 3 Dendrogram graph from Cluster analysis based on ownership information from the 11 vases. Horizontal axis = the participants. Vertical axis = distance between the participants

The Cluster Analysis method relies upon the researcher to define the groups. There is a trade-off to be made when defining the clusters, if there are too many clusters these are more demanding to work with but offer a high level of accurate information about the participants. On the other hand, if there are too few clusters, the information is less accurate but is easier to work with. From the data, three groups with similar distances could be identified in the dendrogram tree. Therefore, three clusters were created. Cluster one had 29 participants, cluster two had 18 participants

and cluster three had 24 participants. A distribution of how the three clusters perceived the *desire to own* for the different vases can be seen in Table 3.

Table 3 Comparison table for the 11 vases against the three ownership values

	Don´t want to own vases		Maybe want to own vases	Want to own vases
Cluster 1	1, 2, 3, 4, 5 and 8	**Common: 1 - 5**	6, 7 and 10	11
Cluster 2	1, 2, 3, 4, 5, 6, 7 and 8		9 and 11	10
Cluster 3	1, 2, 3, 4, 5 and 6		7, 8, 9, 10 and 11	-

From analysing the backgrounds of the participants in each of the three, specific information could be identified for each of the clusters as showed in Fig. 4 and summarised in

Table 4.

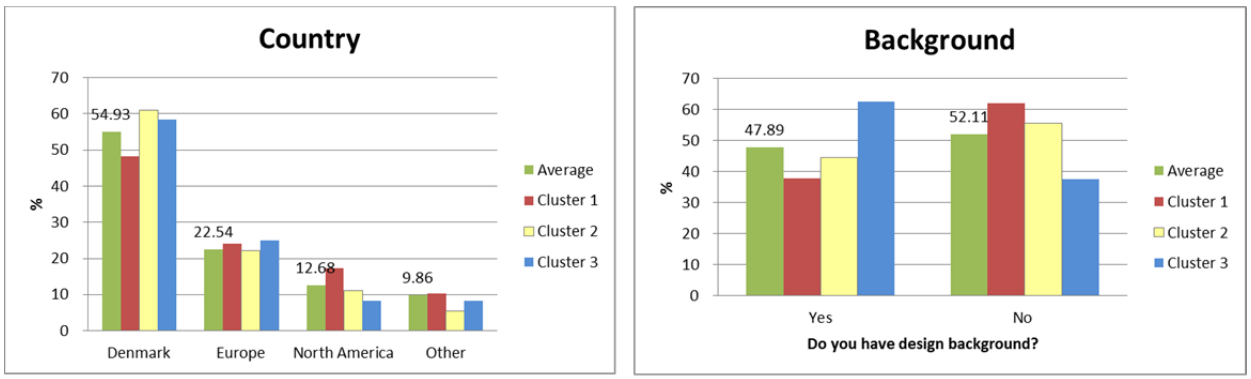

Fig. 4 Background plots for each of the three clusters (example with two background variables)

Table 4 Summary of background information for each of the three clusters

Cluster 1 = 29 people	Cluster 2 = 18 people	Cluster 3 = 24 people
• Mostly from **Denmark, Europe and North America** • With predominant **non design background** • People between **20 and 39** years old. Some also between **40 and 49**. • Majority of **males** • **Minimalistic, Scandinavian and other style**	• Mostly from **Denmark and Europe** • Small difference in design background • People between **20 and 39** years old • Almost **50% males and females** • **Scandinavian, other style and Minimalistic**	• Mostly from **Denmark and Europe** • Majority of people with **design background** • People between **20 and 49** years old • Majority of **males** • **Scandinavian, other style and Country/Traditional**

Prior to presenting the results, the background information from all the surveyed participants, i.e. across the clusters, is summarized. The majority of participants were mainly from Denmark (55%) and with no significant difference between the numbers of people with a design background and those without (from 47% to 52%). The majority of participants were between 20 to 39 years and there were more males than females (62% versus 38%). The predominant styles were Scandinavian and Minimalistic while ‘other style’ was also rated highly. The main differences for the clusters are: Cluster one stands out for having many participants with non-design background. Cluster two differs from the rest in that is composed of half males and half females. Cluster three has a majority of people with design background and with a Country/Traditional style as compared to the other two clusters.

4.3. Data analysis

A four steps data analysis approach was employed to connect the different variables of interest in this study, namely: *desire to own*, perceptions, aesthetics and background of participants. The steps correspond to the different hypotheses being tested and are the following:

1. A series of statistical methods including Correlation Coefficient Analysis (CCA), Principal Component Analysis (PCA) and a Factor Analysis (FA) were performed for each of the clusters to identify any significant relations between the *desire to own* the vase and the adjectives of perception selected to describe it. (Hypothesis 1).

2. The relationships between the perceptions and the geometrical parameters from the product form were analysed by first identifying a series of parameters for the shape, finish and colour to describe the vases. These were later related to the perceptions through conducting Correlation Coefficient Analysis (CCA) and Multiple Regression Analysis (MRA). (Hypothesis 2).

3. Through comparing the findings from both step one and two, it was possible to relate the *desire to own* the vases and the aesthetic parameters.

4. In addition, extended data analysis was performed to understand how the backgrounds of the participants (in particular country and gender) influence the answers for the *desire to own* and also for *beauty*. The lmerTest method was used for this purpose. (Hypothesis 3 and 4).

Each statistical method provided different insight into the relationships investigated, the methods are summarised here:

- The CCA (as described earlier in section 3.1) was used to find significant correlations between two variables (*desire to own* and perceptions; perceptions and aesthetic parameters) (Hypothesis 1 and 2).

- PCA was applied to investigate relationships between *desire to own* and perceptions (Hypothesis 1). The purpose of the PCA is to reduce dimensionality in datasets where there are several interrelated variables, at the same time that it preserves the variation in the dataset as much as possible (Jolliffe 2002). This is achieved by changing the original variables into a new set of artificial variables, called principal components. A principal component is an artificial variable made up of linear combinations of observed variables. The number of principal components generated by the PCA is equal to the original number of variables observed. However, not all principal components are kept after the analysis since only the first ones provide meaningful amount of variance. The first principal component extracted from the analysis provides the maximum amount of variance from the original variables. This means that the first principal component is correlated with some of the variables investigated. The second principal component also provides the maximum amount of variance for the data, that was not considered by the first principal component, to observed variables but to those with no relation with component one. The second component is also completely uncorrelated with the first component, that is, they are independent (Hatcher 1994). Three factor loadings are the minimum number to consider for each cluster and the values for them should be above 0.4 or -0.4 to be significant (Hatcher 1994). PCA provides a visual representation of the variables investigated.

- FA was applied to investigate relationships between *desire to own* and perceptions (Hypothesis 1). FA is a multivariate data technique used to reduce dimensionality. It assumes that a reduced number of latent factors affect the measured variables. It is possible that these latent factors affect several of the variables, which is the reason why they are called *common factors*. Each variable is therefore considered to depend on a linear combination of the common latent factors (Mathworks 2012). The selection of the number of factors depends on the researcher and his/her will to have a simpler explanation model versus a model that fits the data better. Factors with an eigenvalue above 1,0 provide more information than the variables in the data set and were kept (3 factors in this case). Factors with an eigenvalue below 1,0 do not provide more information than the initial variables and cannot be used to reduce dimensionality. The cumulative % shows the amount of information accounted for by the factors of each cluster.

- The MRA was used to find the combinations of aesthetic parameters that could be perceived as a perception describing the vases (Hypothesis 2). That is, the significant variables have to be present at the same time for something to be perceived in a specific way. MRA finds the relationship between several independent variables (the aesthetic parameters) and a dependent variable (each of the perceptions) (StatSoft 2013).

- The lmerTest was used to investigate the influence of the country variable on the *desire to own* and of gender on the *beauty* of a vase (Hypothesis 3 and 4). The purpose was to identify if factors related to the background of participants affect how products are perceived. The lmerTest is a mixed linear model used to analyse complex datasets. The test can handle missing observations and incomplete consumer preference data, and can handle more complex structured data (i.e. more variables) and larger datasets. An interesting part of the test is that it is able to show interactions between variables. It additionally offers more accurate results when the independent variables are a mix of categorical and quantitative effects, as is the case with this research (Kuznetsova *et al.* 2015b).

  The statistics tool chosen to analyse the data of the vases was the R-package lmerTest, an open source package for the R-software which among other things can perform automated complex mixed modelling analyses (Kuznetsova *et al*. 2015a). The packgage uses the generic mixed model R-package lme4, (Bates *et al*. 2014) and is freely available from http://www.r-project.org. Mixed models were selected over the traditional simple ANOVA approach due to the generation of prediction models that are able to account correctly for random samples, that is, the results would also be valid for the elements analysed outside of the dataset (in this case: the participants and the population of vases chosen). Mixed models combine the fixed effects from the ANOVA analysis with the random effects. The benefit of using mixed models was that they provided more accurate information regarding the uncertainty of variables than ANOVA. The disadvantage was the high complexity of the model that made data handling and the communication of results a challenge (Kuznetsova *et al*. 2015b). The lmerTest has been applied on consumer preference for food, with a similar approach using consumer background, food characteristics (equivalent of product features), and perception adjectives and desire (Kuznetsova *et al*. 2015b).

  The building of the mixed model required careful consideration to identify the effects to consider as random and those to consider as fixed. As a rule of thumb, all effects that had been randomly sampled should be considered random. In the vase case, participants were considered random effects because one is interested in the whole population of consumers rather than just the ones that were surveyed. The same applied to the vases. It was of interest to be able to explain all vases and not just the 11 concepts from this study. The next important question involved the selection of the model approach. In principle, one would like to have a model with all the possible effects included, and thus the challenge was to simplify and reduce the model given that variables can be too many for the amount of data available. This posed the issue of selecting which effects to remove, either random or fixed, and in what order. The lmerTest *step* function did this automatically by simplifying the random and the fixed effects of the mixed model separately one at a time: first the random and then the fixed (Kuznetsova *et al*. 2015b). The output of the function was the best model, including p-values for the random and the fixed effects, population means or least squares means estimates (LSMEANS) and comparison test in addition to confidence intervals.

4.4. Validity and reliability

A summary of the statistical validity and reliability of the research process and results is provided here. Semantic Differential (SD) scales were used to obtain data on perceptions from participants as they are valid scales accepted in the research field. Cochran's formula was calculated to determine the confidence levels and confidence intervals for the data from the survey. From our survey with 71 participants we are able to represent the Danish adult population of 2 million people with a 95% confidence level and a confidence interval of 11,63%. Cronbach's alpha was used to determine the reliability of the survey, being the alpha value of 0,6. From applying mixed models (i.e. the lmerTest) and extracting the results from these, the actual sampling error from the data has been taken into account in the proper way by treating data as random samples so results could be generalized outside the dataset. The mixed model takes the level of lack of agreement into account in the way the modelling and the analysis is performed. The lmerTest is a stablished approach in consumer preference for food (Kuznetsova *et al.* 2015b).

5. RESULTS

The statistical analyses explained above were applied to the data (that was clustered as described earlier) to test the different hypotheses proposed in section 3.1 Hypotheses. The following sub-sections focus on analysing and reporting one hypothesis at a time.

5.1. Relationship between *desire to own* and perception (H1)

Three statistical analyses were carried out to examine the relationship between the *desire to own* and the adjectives describing perceptions of the vases. From the Correlation Coefficient Analysis (CCA), significant correlations were found between ownership and the following adjectives to describe perception: *beautiful*, *expensive* and *elegant* for all three clusters (marked in grey in

Table 5). Two other adjectives, *exciting* and *common*, were also found to be significantly related to ownership although this was only true for two out of three clusters. *Exciting* was common for cluster one and two, while *common* was shared by cluster two and three. *Dynamic* was significant only for cluster 1.

Table 5 Results for the CCA for the three clusters (only those with p<0,05 are shown, i.e. significant). The negative sign of r indicates that the first perception of the pair, and not the second, is positively related to ownership.

Perceptions related to ownership for cluster 1	**Correlation coefficient (r)**	**p value**	**r2**	**% explained**
Ugly / Beautiful	0,948	0,001	0,899	89,91
Cheap / Expensive	0,760	0,006	0,578	57,78
Dull / Exciting	0,937	0,001	0,879	87,87
Clumsy / Elegant	0,942	0,001	0,887	88,67
Dynamic / Static	-0,683	0,020	0,467	46,69
Perceptions related to ownership for cluster 2	**Correlation coefficient (r)**	**p value**	**r2**	**% explained**
Ugly / Beautiful	0,975	0,001	0,951	95,10
Cheap / Expensive	0,897	0,001	0,804	80,45
Common / Uncommon	-0,885	0,001	0,782	78,25
Dull / Exciting	0,791	0,004	0,625	62,52
Clumsy / Elegant	0,931	0,001	0,867	86,74
Perceptions related to ownership for cluster 3	**Correlation coefficient (r)**	**p value**	**r2**	**% explained**
Ugly / Beautiful	0,988	0,001	0,976	97,58
Cheap / Expensive	0,606	0,048	0,367	36,73
Common / Uncommon	-0,837	0,001	0,701	70,06
Clumsy / Elegant	0,957	0,001	0,915	91,52

A Principal Component Analysis (PCA) was carried out to identify the perceptions that were related or perceived similarly. Table 6 shows the comparison of the Principal Components factor loadings for the three clusters. The bold text indicates the perceptions that scored above 0,4 or -0,4 on the factor loading. The perceptions in each Principal Component are perceptions that are related to each other and move together.

Table 6 Principal Component loadings for the three clusters. The bold indicates the perceptions that scored above 0,4 or -0,4 on the factor loading

	Cluster 1	Cluster 2	Cluster 3
1st PC	**Beautiful**	**Beautiful**	**Beautiful**
	Elegant	**Elegant**	**Feminine**

	Feminine	**Feminine**	**Common**
2nd PC	**Passive**	**Artificial**	**Artificial**
	Feminine	**Elegant**	Elegant
	Organic	**Masculine**	Beautiful

From the PCA, *beautiful* and *feminine* were found to be perceptions for the first Principal Component (PC) that were common across all three clusters; *elegant* was only shared by two clusters, number one and two; while *artificial* and *elegant* were found to be common for two clusters in Principal Component two. Another output of the analysis was the principal component space shown in Fig. 5., which gives an overview of how the vases are perceived. The vases that are represented close to each other in the graph were perceived similarly, eg. vase 1, 2, 3 on the left side of Fig. 5. PC1 is represented in the horizontal axis, while PC2 is represented in the vertical axis. For example, the vases on the right hand side of the plot (no. 9, 10 and 11) are perceived as *beautiful, elegant, exiting* and *expensive* because the perception vectors are pointing towards that direction. Similarly, vases number 1, 2, 3 and 7 are perceived as *masculine, artificial* and *uncommon* because the vectors for those perceptions point that way. From PCA, three groups of vases can be seen as indicated by the squares in Fig. 5. The analysis reveals perceptions that are similar for these. In Fig. 5, the perception *beautiful* is close to the horizontal axis and pointing to the right. This means that the vases on the right of the origin of coordinates are perceived as *beautiful*, while the ones on the left side are considered further away from *beautiful*, i.e. *ugly*., as *Ugly / Beautiful* were a pair of perceptions. The vector for *ugly* is the extension of vector *beautiful* across the origin (see red line on the right of the graph). The same applies to all other perception pairs.

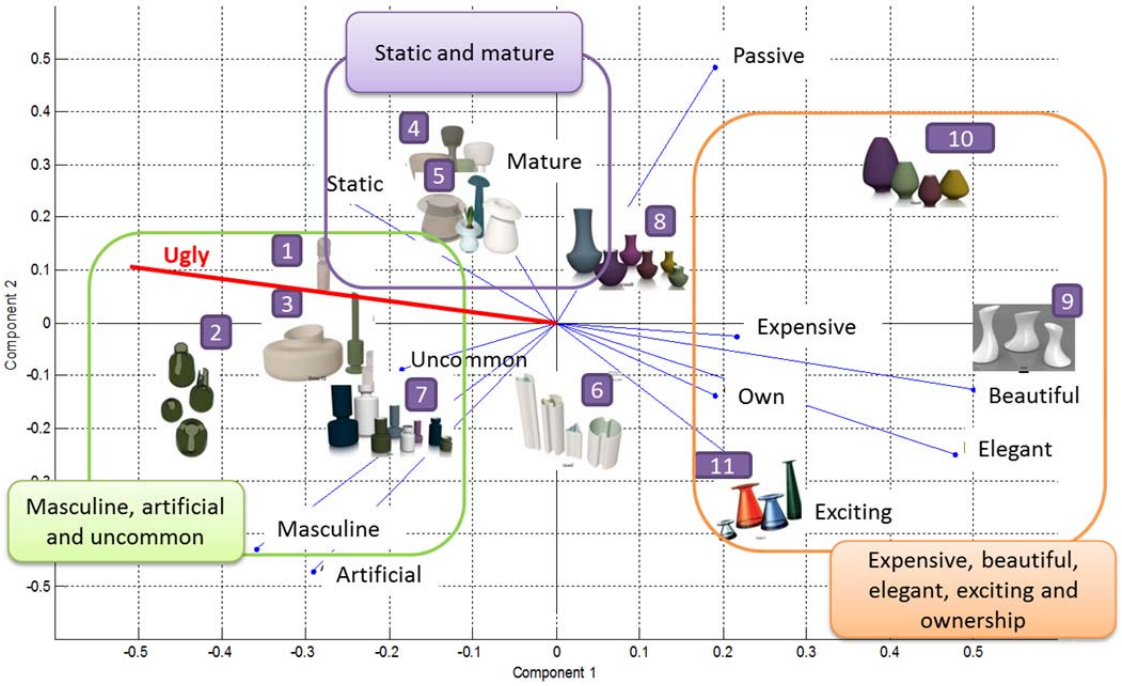

Fig. 5 PC space for the first cluster. Horizontal axis= PC1, vertical axis=PC2., squares indicate group of vases that are perceived similarly.

From the FA it was possible to identify the adjectives (describing perceptions) that moved together and were therefore related. The perceptions that moved together or had something in common with *ownership*, that were particularly interesting were: *beautiful* and *elegant* for the three clusters while *expensive* and *exciting* were shared by cluster one and two. Perceptions *aggressive, masculine* and *artificial* were also found to be moving together for the three clusters, whereas *mature* was an independent adjective. The three groups of perceptions moved independently from each other (see Table 7). The cell with the highest positive or negative value (from -1 to +1) out of the three loading columns is marked in grey as that loading is the one that provides the most information. The sign indicates if the loading relates to the first (negative sign) or second (positive sign) adjective of the pair.

Table 7 Summary of results from the FA of the three clusters. The negative sign indicates that the relationship is with the first perception of the pair.

	Loadings for cluster 1			**Loadings for cluster 2**			**Loadings for cluster 3**		
Factor	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Own	0,980	-0,089	-0,068	0,922	0,302	0,200	0,994	-0,061	-0,015
Ugly (-) / Beautiful (+)	0,922	-0,315	-0,179	0,951	0,300	0,034	0,983	-0,170	0,018
Aggressive (-) / Passive (+)	-0,039	-0,970	-0,165	0,129	0,847	0,043	0,264	-0,819	-0,310
Cheap (-) / Expensive (+)	0,769	-0,410	0,162	0,766	0,530	0,097	0,018	0,430	0,161
Common (-) / Uncommon (+)	-0,490	0,251	0,831	-0,837	-0,114	-0,366	-0,825	0,299	0,391
Boring (-) / Exciting (+)	0,977	0,084	0,184	0,859	0,174	-0,345	0,519	0,128	0,836
Clumsy (-) / Elegant (+)	0,950	-0,199	-0,085	0,977	0,114	0,037	0,961	-0,084	0,159
Feminine (-) / Masculine (+)	-0,306	0,945	0,071	-0,367	-0,817	-0,023	-0,287	0,897	0,025
Youthful (-) / Mature (+)	-0,508	-0,084	-0,736	0,096	0,060	0,991	0,488	-0,246	-0,787
Organic (-) / Artificial (+)	-0,179	0,933	0,090	-0,159	-0,985	-0,026	-0,019	0,923	-0,059
Significant tests									
Eigenvalues	5.639	2.693	1.186	6.186	1.798	1.261	4.948	2.554	1.328
Cumulative %	93,50%			90,90%			85,60%		

The above results show that relations existed among some of the perceptions and these included associations with *desire to own*. Perceptions *beautiful, elegant, expensive* and *exciting* (all positive perceptions) were among the most commonly mentioned adjectives that showed relations with *desire to own* from the different analyses and hence were determining perceptions to investigate further for the links between *desire to own* and the aesthetic features of products. This is described in the following sections. Other perceptions such as *dynamic, common, feminine* and *organic*, which are not positive or negative on their own, where also found to be correlated to the *desire to own* but only for some of the clusters.

5.2. Relationship between perceptions and aesthetics (H2)

In order to investigate the relationship between perceptions describing the products and aesthetic features, physical features were measured from the vase concepts (see Fig. 6). The properties were counted manually using the formulas in Table 8. The aesthetic features considered included shape, finish and colour parameters and were measured and converted into ratios to ease the comparison with perceptions. Table 8 shows the procedure used to calculate the ratios of the aesthetic features. The results are expressed in percentage. The ratio formulas are of benefit to researchers who would utilise the formulas to evaluate design in other contexts (i.e. other products) or those working in generation for example with shape grammars, and would apply to other products. Defining what levels make the product reach a particular perception may change with the product category. Hence this is not specific to the vase. Straight and curved lines, acute and obtuse angles, and curved and sharp corners are properties based on previous research (Van Bremen *et al*. 1998; Hsiao and Chen 2006; Achiche and Ahmed-Kristensen 2011). While symmetry planes (regularity level), visual gravity point, complexity (i.e. no. of independent modules), vertical or horizontal vase, brilliant or dull vase, transparent or solid vase, cold or warm colour, low or high brightness, and low or high chroma were properties originally considered for this study. The aesthetic features considered were chosen as they were considered relevant for the study of vases. Other products may need to use other aesthetic properties (or a subset). Not all properties might be relevant for all product categories. For example symmetry planes are relevant to vases because they can vary and can have an influence on the perception. However for cars this property might not be relevant since all cars are symmetric. The parameters selected for study should belong to different categories such as materials, colour, proportion, ornamentation, shape, size and reflectivity when appropriate, which according to Brunel and Kumar (2007) have a big influence on the aesthetic perception of products.

Fig. 6 Example of aesthetic parameter's measured on a vase

Table 8 Ratios formulas for the aesthetic parameters considered for the vases

Lines Curves Ratio (LCR) $LCR = \frac{NL}{NL + NC} 100$ (1) NL = no. of lines NC = no. of curves	**Acute Obtuse Angle Ratio (AOR)** $AOR = \frac{NAA}{NAA + NOA} 100$ (2) NAA = no. of acute angles NOA = no. of obtuse angles	**Curved Sharp Corner Ratio (CSCR)** $CSCR = \frac{NRC}{NRC + NSC} 100$ (3) NRC = no. of round corners NSC = no. of sharp corners
Regularity Level (RL) $RL = \frac{\Sigma_1^i R_i}{j} 100$ (4) R = nr of symmetry planes per vase j = nr of total symmetry planes (j=3)	**High Low Gravity Point Ratio (HLGPR)** $HLGP = \frac{HGP}{HGP + LGP} 100$ (5) HGP = high gravity point LGP = low gravity point	**Complexity level (CPL)** $CPL = \frac{no.of.\text{modules}}{1vase}$ (6) If CPL = 2 then the vase is complex (100% CPL) If CPL = 1 then the vase is simple (0% CPL)
Vertical Horizontal Aspect Ratio (VHR) $VHR = \frac{NVV}{NVV + NHV} 100$ (7) NVV = no. of vertical vases NHV = no. of horizontal vases	**Brilliance Dull Ratio (BDR)** $BDR = \frac{NBV}{NBV + NDV} 100$ (8) NBV = no. of brilliant vases NDV = no. of dull vases	**Transparent Solid Ratio (TSR)** $TSR = \frac{NTV}{NTV + NSV} 100$ (9) NTV = no. of transparent vases NSV = no. of solid vases
Cold Warm ratio (CWR) $CWR = \frac{C}{C + W} 100$ (10) C = cold colour W = warm colour	**Low High Brightness ratio (LHBR)** $LHBR = \frac{LB}{LB + HB} 100$ (11) LB = low brightness HB = high brightness	**Low High Chroma ratio (LHCR)** $LHCR = \frac{LC}{LC + HC} 100$ (12) LC = low chroma HC = high chroma

A Correlation Coefficient Analysis (CCA) and a Multiple Regression Analysis (MRA) were performed on the dataset consisting on the three clusters together. The CCA was used to detect which aesthetic parameters affect each of the different perceptions, i.e. individual effect of aesthetic parameters on the perceptions. The MRA was used to find which

combination of aesthetic parameters affected each of the perceptions, i.e. combined effect of several aesthetic parameters on single perceptions. Results from the CCA (see Table 9) were a series of design rules linking individual perceptions to several aesthetic parameters. From the table it can be seen that each perception is related to a number of shape parameters, except for *Common / Uncommon* and *Dynamic / Static*. The sign of the correlation coefficient (r) indicates if the shape parameter is positively or negatively correlated with the perception. For example, in the case of *Ugly / Beautiful*, it is negatively correlated to the Line Curve Ratio (LCR) and to the Complexity Level (CPL), and positively correlated to the Vertical Horizontal Aspect Ratio (VHAR). This means that vases are perceived as *beautiful* when there are low number of lines, low complexity and high vertical aspect ratio. That is, more *beautiful* vases the more curves and the less lines they have, the more simple and with a vertical aspect ratio (i.e. tall). The same reading applies to the other perceptions in the table.

Table 9 Results summary from CCA between perceptions and aesthetic parameters (only those with p<0,05 are shown, i.e. significant)

Perceptions	Shape parameter	Corr. Coeff. (r)	p value	r2	% explained
Ugly (-) / Beautiful (+)	Lines Curves Ratio (LCR)	-0,633	0,037	0,401	40,09
	Complexity Level (CPL)	-0,743	0,009	0,551	55,14
	Vertical Horizontal Aspect Ratio (VHR)	0,640	0,034	0,409	40,90
Aggressive (-) / Passive (+)	Lines Curves Ratio (LCR)	-0,850	0,001	0,723	72,28
Cheap (-) / Expensive (+)	Lines Curves Ratio (LCR)	-0,646	0,032	0,417	41,72
	Complexity Level (CPL)	-0,679	0,022	0,461	46,08
	Vertical Horizontal Aspect Ratio (VHR)	0,715	0,013	0,511	51,05
Common (-) / Uncommon (+)	-				
Boring (-) / Exciting (+)	Complexity Level (CPL)	-0,685	0,020	0,469	46,93
	Vertical Horizontal Aspect Ratio (VHR)	0,621	0,042	0,385	38,54
Clumsy (-) / Elegant (+)	Complexity Level (CPL)	-0,716	0,013	0,512	51,21
	Vertical Horizontal Aspect Ratio (VHR)	0,668	0,025	0,446	44,59
	Low High Chroma ratio (LHCR)	-0,623	0,041	0,388	38,84
Feminine (-) / Masculine (+)	Lines Curves Ratio (LCR)	0,907	0,000	0,822	82,24
Youthful (-) / Mature (+)	Brilliance Dull Ratio (BDR)	-0,706	0,015	0,498	49,84
Dynamic (-) / Static (+)	-				
Organic (-) / Artificial (+)	Lines Curves Ratio (LCR)	0,846	0,001	0,716	71,60

The Multiple Regression Analysis (MRA) identifies the existence of any particular combination of product features that would generate a certain perception (see Table 10). The positive and negative sign of the coefficient estimates indicates if the relation to the perception is positive or negative. From this analysis it was found that a negative AOR (that is, more obtuse angles than acute angles), a negative HLGRP (that is, a low gravity point) and a positive VHR and BDR (that is, a vertical and brilliant vase) would be perceived as an *elegant* vase if all elements were present at the same time.

Table 10 Results from MRA on perceptions and aesthetic parameters (only those with p-value<0,05 are shown, i.e. significant)

Elegant	b (coeff. estimates)	t-test	p-value
Acute Obtuse Angle Ratio (AOR)	-0,743	-14,975	0,043
High Low Gravity Point Ratio (HLGPR)	-2,577	-14,585	0,044

Vertical Horizontal Aspect Ratio (VHR)	1,631	20,319	0,031
Brilliance Dull Ratio (BDR)	1,820	13,342	0,048

Line Curve Ratio (LCR), Complexity Level (CPL) and Vertical Horizontal Aspect Ratio (VHR) are parameters that affect the perception of many adjectives describing vases.

5.3. Design rules

The results from the first and second phases were compared to identify which aesthetic parameters could be related to the *desire to own* through the perceptions. The outcomes of that comparison would be a second set of design rules that would target design to increase a *desire to own*. Some perceptions were already identified as being significantly related to the *desire to own*: *beautiful, elegant, expensive* and *exciting*. Looking at the aesthetic parameters of those perceptions, it was found that they share low complexity and high vertical horizontal aspect ratio (see Table 11).

Table 11 Comparison of aesthetic parameters and perceptions from CCA

Perceptions linked to ownership	**Aesthetic parameter related to**	**Implication or reading**
Beautiful	Low LCR, low CPL and high VHAR	More curves than lines, simple and vertical
Elegant	Low CPL, high VHAR and low LHCR	Simple, vertical and high chroma
Expensive	Low LCR, low CPL and high VHAR	More curves than lines, simple and vertical
Exciting	Low CPL and high VHAR	Simple and vertical

5.4. Influence of the background information of the participants on *desire to own* and *beauty (H3 and H4)*

To understand if the background of the participants had an influence on the *desire to own* a vase or upon the perception of *beauty* from a vase, the *lmerTest* function described above was applied to the analysis of these two variables. The first analysis calculated the background variables that influence the *desire to own* a vase (ownership), while the second analysis calculated the background variables that influence the perception of *beauty* from a vase.

Both, perception variables and aesthetic features were summarized in fewer variables with the help of Principal Component Analysis (PCA). From that PCA, two Principal Components (PC) were identified for the perceptions and two for the aesthetic properties of the vases. These were: PC1 perceptions: a combination of *beautiful, expensive* and *elegant*; PC2 perceptions: a combination of *mature, static* and *dull*; PC1 aesthetics: a combination of *high gravity point, cold colour* and *brilliant;* and PC2 aesthetics: a combination of *complex, low chroma* and *curved corners*. The *desire to own* was not included in the PCA of the perceptions since it was the variable to be calculated. Table 12 shows the perceptions belonging to each of the principal components. As explained in section 4.3 Data analysis, the first principal components provide the most variance and are completely uncorrelated. The bold text indicates the perceptions that scored above 0,4 or -0,4 on the factor loading. The non-bold of some of the perceptions indicates that these perceptions didn't score above 0,4 or -0,4 on the factor loadings but they are kept in the principal component as they were close to those values and because it is accepted that three is the minimum number of variables to include in the principal component (Hatcher 1994).

Table 12 Definition of the Principal Components for perceptions and aesthetics. The bold indicates the perceptions that scored above 0,4 or -0,4 on the factor loading

PC1 perceptions	PC2 perceptions	PC1 aesthetics	PC2 aesthetics
Beautiful Expensive Elegant	**Mature** **Static** **Dull**	**High gravity point** **Cold colour** Brilliant	**Complex** **Low chroma** **Curved corners**

5.5.1. Analysis of Desire to own (H3)

For the study of the *desire to own* a vase in relation to the background of the participants, the following variables were considered: *desire to own* (ownership), vase no., participant, country, age, gender, design background, style, PC 1 and PC 2 of the perceptions, and PC 1 and PC 2 of the aesthetic features. This was for the dataset of 71 participants answering the questions for all 11 vases resulting in 781 total data points (observations).

After checking that the PCs of perceptions and aesthetics had linear relations and not quadratic relations, the analysis proceeded with the creation of the mixed model. This check was performed in order to identify which model would fit the data better, a linear one or a quadratic one. The analysis of the *desire to own* a product followed an iterative process:

- First, the *lmerTest* was applied to the background of the participants to find the significant background variables related to the *desire to own* a vase. Results showed that participants were significant with a p-value below 0.05 for the random effects. Vase and the interaction between country and vase (Country:Vase) were significant fixed effects with a p-value lower than 0.05. These variables continued to the next test round, together with variable country (this was not significant individually in the test but needed to be kept as it was significant when in combination with vase). The ':' sign between variables meant there was interaction between the two variables, i.e. for Country:Vase, vase moderated the effect of country. This interaction meant that the participants' country alone could not explain the *desire to own* a vase, but the combination of Country and Vase may.
- Second, the *lmerTest* was applied to the significant background variables (identified in the previous step) and the interaction of aesthetic features with those background variables. The background variables were considered random because one wants to explain the demographic of the consumers in general and not only the participants from the survey. This model included the PC perceptions and the PC aesthetics as fixed effects. Results show that participants and the interaction between PC2 aesthetics and the participants (PC2aesthetics:Participants) are significant for the random effects (see Table 13). PC1 and PC2 of the perceptions and PC1 and PC2 of the aesthetics are significant for the fixed effects (Table 14).
- Third, the lmerTest was applied only to the significant random and fixed variables from the previous step. Results from this post-hoc analysis showed that only PC1perceptions, PC2 perceptions and PC1 aesthetics were significant (see Table 15). The sign of the estimate column indicated that PC1perceptions (a combination of *beautiful, expensive* and *elegant*) was positively correlated with the *desire to own* a vase, i.e. that a higher level of *desire to own* is expected when the product is perceived as *beautiful, expensive* and *elegant*. PC2 perceptions (a combination of *mature, static* and *dull*) and PC1 aesthetics (a combination of *high gravity point, cold colour* and *brilliant*) were negatively correlated to the *desire to own*; i.e. those perceptions or aesthetic features negatively influenced the *desire to own*. The background of the participants was not significant.

Table 13 Random effects results for the final model of desire to own *(significant in bold). The ":" indicates there is an interaction between the variables.*

Random variables	Chi.sq	Chi.DF	elim.num	p-value
PC1perceptions:Participant	0.000	1	1	1.000
Vase	0.803	1	2	0.370
PC1aesthetics:Participant	1.071	1	3	0.301
PC2perceptions:Participant	1.556	1	4	0.212
Vase:Country	2.184	1	5	0.139
Participant	**27.007**	**1**	**keep**	**0.000**
PC2aesthetics:Participant	**12.056**	**1**	**keep**	**0.001**

Table 14 Fixed effects results for the final model of desire to own *(significant in bold). The ":" indicates there is an interaction between the variables.*

Fixed variables	Sum Sq	Mean Sq	Num DF	DenDF	F-value	elim.num	p-value
Country:PC2aesthetics	1.616	0.539	3	524.900	1.651	1	0.177

Country:PC1perceptions	0.644	0.215	3	128.931	1.193	2	0.315
Country:PC1aesthetics	1.184	0.395	3	631.952	0.847	3	0.468
Country:PC2perceptions	2.370	0.790	3	658.321	2.238	4	0.083
Country	1.184	0.395	3	66.980	1.209	5	0.313
PC1perceptions	**37.929**	**37.929**	**1**	**635.889**	**64.319**	**keep**	**0.000**
PC2perceptions	**5.43635**	**5.436**	**1**	**635.889**	**30.168**	**keep**	**0.000**
PC1aesthetics	**5.014**	**5.014**	**1**	**635.889**	**20.296**	**keep**	**0.000**
PC2aesthetics	**1.6752**	**1.6752**	**1**	**544.711**	**5.103**	**keep**	**0.024**

Table 15 Post-hoc analysis results for desire to own *(significant in bold)*

Variables	Estimate	Std. Error	t-value	p-value
(Intercept)	-0.399	0.042	-9.469	0.000
PC1perceptions	**0.184**	**0.039**	**4.765**	**0.003**
PC2perceptions	**-0.094**	**0.029**	**-3.263**	**0.017**
PC1aesthetics	**-0.064**	**0.024**	**-2.676**	**0.037**
PC2aesthetics	0.074	0.053	1.396	0.208

5.4.2. Analysis of beautiful (H4)

The perception *beautiful* was also analysed since it was found to be highly correlated to the *desire to own* a vase in (Perez Mata et al. 2013). The analysis of *beautiful*, although following the same methodology to the analysis of the *desire to own* (i.e. the lmerTest), included a different set of variables. The background variables of the participants were kept but the principal components for the perceptions were removed from the analysis. This left a model that analysed the influence of the background of the participants and of the physical properties of the vases on the perception of *beauty*. The vases were again ordered by increasing *beauty*, i.e. from lowest to highest perception of *beauty*, which differs from the order in Fig. 2. This was done to ease the interpretation of the results from the tests when using tables and plots. As before, the analysis followed three steps:

- First, *lmerTest* was employed to find the significant background variables. Results showed that participants are significant for the random effects. Gender, vase and the interaction between country and vase (Country:Vase), were significant for the fixed effects.
- Second, the *lmerTest* was applied to the significant background variables (from the previous step) and the interaction of aesthetic features with the background variables. These were considered random because one wants to explain the background of the consumers in general and not only the participants from the survey. The aesthetic features were included as fixed effects in the model. Results show that vase, participants and the interaction between PC2 aesthetics and participants (PC2 aesthetics:participants) were significant for the random effects (see Table 16). Gender and PC2 aesthetics were significant for the fixed effects (see Table 17).
- Third, the lmerTest was applied only to the significant random and fixed effects from the previous step. Results from this post-hoc analysis showed that gender was the only significant background variable that could explain changes in the perception of *beauty* from a vase (see Table 18). Gender had a significant positive value, that is, the females rated the vases as more *beautiful* than men with a value of 0.287 (taken from the estimate column) on the scale of *beautiful* (see Table 2). This scale has levels from -3 to +3, which makes the value of 0.287 a very small value to make a rating of *beauty* belong on a different level on the *beauty* scale. PC2 aesthetics (a combination of *complex, low chroma* and *curved corners*) was found to be negatively correlated to *beautiful*, that is, vases with those characteristics would not be perceived as *beautiful*.

Table 16 Random effects results for the final model of beautiful *(significant in bold). The ":" indicates there is an interaction between the variables.*

Random variables	Chi.sq	Chi.DF	elim.num	p-value
Vase:Gender	0.000	1	1	1.000

PC1aesthetics:Participant	0.261	1	2	0.609
Vase	**18.645**	**1**	**keep**	**0.000**
Vase:Country	3.431	1	keep	0.064
Participant	**16.352**	**1**	**keep**	**0.000**
PC2aesthetics:Participant	**10.563**	**1**	**keep**	**0.001**

Table 17 Fixed effects results for the final model of beautiful *(significant in bold). The ":" indicates there is an interaction between the variables.*

Fixed variables	Sum Sq	Mean Sq	NumDF	DenDF	F.value	elim.num	p-value
Country:PC2aesthetics	0.038	0.013	3	34.173	0.049	1	0.985
Country:PC1aesthetics	2.984	0.995	3	26.916	0.705	2	0.558
Country	3.025	1.008	3	44.216	0.516	3	0.674
Gender:PC1aesthetics	0.803	0.803	1	630.650	0.339	4	0.560
PC1aesthetics	0.186	0.186	1	7.957	0.113	5	0.745
Gender:PC2aesthetics	1.482	1.482	1	70.185	0.791	6	0.377
Gender	**6.623**	**6.623**	**1**	**69.918**	**4.476**	**keep**	**0.038**
PC2aesthetics	**24.022**	**24.022**	**1**	**9.900**	**16.407**	**keep**	**0.002**

Table 18 Post-hoc analysis results for beautiful *(significant in bold)*

Variables	Estimate	Std. Error	t-value	p-value
Intercept	-0.204	0.192	-1.062	0.309
Gender	**0.287**	**0.136**	**2.116**	**0.038**
PC2aesthetics	**-0.446**	**0.110**	**-4.051**	**0.002**

6. DISCUSSION

Results showed that the perceptions found to significantly correlate to the *desire to own* a vase are: *beautiful, expensive, elegant, exciting, feminine, common* and *dynamic*. Out of all these, only the first four are shared across the three clusters and are additionally positive perceptions. The rest are neither shared nor positive perceptions (i.e. they are neutral). This result confirms hypothesis 1 (H1) which stated that positive perceptions (*beautiful, expensive, elegant* and *exciting*) would positively correlate to the *desire to own*, and points towards investigating the influence the background of the participants has on *desire to own* and perceptions since differences were found for each cluster.

Some aesthetic parameters were found to correlate to some perceptions; Line Curve Ratio (LCR), Complexity Level (CPL) and Vertical Horizontal Aspect Ratio (VHR) are parameters that affect the perception of many adjectives describing vases. It is therefore believed that those three parameters are important for the design of vases. A set of hypotheses were tested relating perceptions to aesthetic parameters (Hypotheses 2). Results have shown the following:

- H2a stated that *beautiful* vases would have more curves than straight lines (i.e. low Line Curve Ratio), would be simple (i.e. low Complexity Level) and tall (i.e. high Vertical Horizontal Ratio). This was confirmed for all three properties: curves, simple and tall.
- H2b stated that *aggressive* would have more straight lines than curves (i.e. high Line Curve ratio), more acute angles than obtuse angles (i.e. high Acute Obtuse ratio) and low symmetry (i.e. low Regularity Level). The results confirmed the higher number of lines as having a significant influence on *aggressive* vases, but it was not the case for the acute angles or the lack of symmetry, partially confirming this hypothesis.

- H2c stated that *expensive* vases would be tall (i.e. high Vertical Horizontal Ratio). This was confirmed by the results. Additionally, it was found that for vases, more curves than straight lines (i.e. low Line Curve Ratio) and simplicity (i.e. low Complexity Level) had a positive impact on *expensive*.
- H2d stated that *masculine* vases would have more straight lines than curves (i.e. high Line Curve Ratio) and sharp corners and (i.e. low Curved Sharp Corner Ratio). Results have confirmed that straight lines have a significant positive influence, but not the sharp corners, which partially confirms the hypothesis.
- H2e stated that *dynamic* vases would have more curves than straight lines (i.e. low Line Curve Ratio). This hypothesis was rejected as no aesthetic feature significantly influenced this perception for vases.
- H2f stated that *organic* vases would have more curves than straight lines (i.e. low Line Curve Ratio). This was confirmed by the results.

In addition to the perceptions included in the set of hypotheses for Hypothesis 2, four other perceptions (i.e. *uncommon, exciting, elegant* and *mature*) were included in the analysis to test if new relations could be derived from the data. *Uncommon* did not show any significant relation to any of the aesthetic properties analysed in the study. *Exciting* was found to significantly correlate to simplicity (i.e. low Complexity Level) and tall (i.e. high Vertical Horizontal Ratio). *Elegant* was found to significantly correlate to simplicity (i.e. low Complexity Level), tall (i.e. high Vertical Horizontal Ratio), high chroma (i.e. high Low High Chroma Ratio), obtuse angles (i.e. low Acute Obtuse angle Ratio), low gravity point (i.e. low High Low Gravity Point Ratio) and high brilliance (i.e. high Brilliance Dull Ratio). *Mature* was found to significantly correlate to dull (i.e. low Brilliance Dull Ratio).

From the results from Hypothesis1 and the set of hypotheses in Hypothesis 2, it can be concluded that low Line Curve Ratio (i.e. curves), low Complexity Level (i.e. simple), high Vertical Horizontal Aspect Ratio (i.e. tall) and high High Low Chroma Ratio (i.e. high chroma) are the aesthetic parameters correlated to the *desire to own*. Those parameters positively influence the consumer's *desire to own* a product and should be considered during shape generation.

Hypothesis 3 stated that the *desire to own* would be different for people from different countries. However, country was not found to be significantly correlated to the *desire to own* which rejects hypothesis 3 (H3). Nor were the other background variables correlated to the *desire to own*. This shows that despite having participants for the different country backgrounds, genders and age, the effect of the geometry of the design has the greatest influence on the perception and can therefore transcend backgrounds. Hypothesis 4 stated that *beauty* ratings would be higher for women than men. Gender was found to have an influence in the evaluation of the *beauty* of a vase, with females rating the vases 0.287 higher than males. However, that difference was within one category of the scale of *beautiful* (in a seven point scale). Hence, although higher, it was not enough to make female participants belong to another point in the *beautiful* scale. For this reason hypothesis 4 (H4) is rejected.

Previous studies have explored the relationships between aesthetic features and perceptions and developed methods to enhance emotional appeal based upon their findings. These methods range from those following the analogy of communication (Van Bremen *et al*. 1998; Hsiao and Chen 2006; Achiche and Ahmed-Kristensen 2011) to those following the Kansei Engineering approach (Colwill et al. 2003; Schütte and Eklund 2005; Orsborn et al. 2009) or other approaches (Yanagisawa and Fukuda 2005; Lai *et al*. 2005).This research built on the first approaches to determine the relationships for vases and went a step further with the identification of the perceptions evoked when people wanted to own a vase. For research, this study contributes to establishing a methodology to further investigate the influence of perceptions, aesthetics, ownership and the background of consumers in other product categories. Results from these studies contribute through providing insight towards the influence of perception variables across product category and background properties. That information could be embedded as guidelines into shape grammar or parametric modelling approaches for design synthesis purposes. For education, the generation of guidelines for design helps designers obtain design competences faster and to understand the different influential factors of design more accurately. This reduces the reliance on intuition and experience alone. In the area of 3D printing this could also be beneficial when the consumer is the designer. The implications of the research for industry, the possibility of targeting consumers more accurately is a benefit. Including consumers' perception towards the product in the design process together with the influence of the background of different target groups contributes toward the generation of new products that appeal consumers more

accurately and increase the chances of being purchased. The insight obtained from applying the method could be used for designing for emerging markets by applying those rules that transcend backgrounds.

It is acknowledged that the results from this paper are specific to vases although transferable to similar product categories and they demonstrate that these relationships are possible. The research method can also be applied to other product categories. The results are based on the intention of participants to own a product which may differ from the actual purchase. Further work should focus on validation, on the analysis of other perceptions from vases and in extending the analysis to other product categories. It is also acknowledged that relations between ownership and perceptions may differ for other products, i.e. *beautiful* for vases refers to curves, simple and tall, whereas *beautiful* for a car may be different, for example angular. The participants' background was limited to a few known factors (age, gender, style, country and design background). Further work including more background variables in the analysis could be of interest.

7. CONCLUSIONS

A survey with 71 participants evaluating 11 vase concepts was analysed to investigate the relationship between: 1) the *desire to own* a product, 2) the perceptions evoked by the product, 3) the aesthetic features of the product, and 4) the background of the participants. A total of 4 hypotheses were proposed for this study. Hypothesis 1 (H1) proposed that positive perceptions such as *beautiful, elegant, exciting* and *expensive* correlate to the *desire to own* a. Hypothesis 2 (H2) were a set of hypotheses that proposed links between perceptions and aesthetic features. Hypothesis 3 (H3) proposed that differences are expected for the *desire to own* a product between participants with different country of origin. Hypothesis 4 (H4) proposed that differences are expected for the *beauty* ratings of a product between participants with different gender, i.e. women were expected to rate the vases as more *beautiful* than men. Advanced statistical methods, including mixed models (i.e. lmerTest), were used that allow the data to be generalised beyond the sample of 71 participants.

Results showed that the *desire to own* was correlated to positive and neutral perceptions and that no differences in perception were found in the background (within the backgrounds tested). These findings show that certain perceptions relate to a *desire to own* a product, and it is possible, as demonstrated, to identify the aesthetic features that influence a perception. The implications of this are the possibility to define a specification to designers that include these perceptions, and guidelines to designers for how to achieve this perception (through combination of the aesthetic features). In addition, within this case and the limited number of country backgrounds, it was demonstrated that the evaluation of *beauty* went beyond the participants' country of origin, which is significant finding for companies adapting products to new markets. For research, this highlights that there are some aesthetic features associated with perceptions that can transcend cultures and inform designs in new markets.

The main contribution of the paper, beyond the findings, is a method showing how to link four areas: *desire to own*, perceptions, aesthetic features and background of the participants. Additionally, the design rules identified in this study (relating perceptions and aesthetic features) offer guidelines for designers on what parameters are important in the design of vases and how they should be modified to achieve concrete perceptions that can lead to the stimulation of the *desire to own* the vase. These guidelines can additionally be implemented using shape grammars or parametric models to design for synthesis. The background of the participants was found to be independent, which means that designers can design across cultures (at least regarding Europe and North America where our sample was taken). There is a general agreement on what is *beautiful* and of what is *desired to be owned* but in different levels. That is, products would be found *beautiful* in different degrees but still *beautiful*. For the designer this means that it is possible for design to transcend across cultural backgrounds and target customers more accurately.

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